

Synthesis of Silver Nanoparticles by Green Method Using Green Tea Leaves Extract, Morphology, Optical, and Antibacterial Properties of Silver Nanoparticles

Yu Soon Wing¹, Syed Zuhaib Haider Rizvi^{1*}

¹ Department of Physics and Chemistry, Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia (Pagoh Campus), 86400 Pagoh, Muar, Johor, MALAYSIA

*Corresponding Author: syedzuhaib@uthm.edu.my

DOI: <https://doi.org/10.30880/ekst.2024.04.01.031>

Article Info

Received: 28 December 2023

Accepted: 13 June 2024

Available online: 27 July 2024

Keywords

Silver nanoparticles, antibacterial properties, biosynthesis method, green tea extract, SEM, EDX, UV-Vis, zone of inhibition.

Abstract

Silver nanoparticles (AgNPs) is well-known to have antibacterial properties, while biosynthesis method is an environmentally friendly to produced AgNPs. Conventional method often face challenges in safety concerns and nanoparticle aggregation. Therefore, this research was performed to determine the method of synthesizing AgNPs by green tea extract, investigate its morphology, element analysis, optical and antibacterial activity. The AgNPs were produced by mixing 0.01mol/L of silver nitrate solution with green tea extract to get the liquid sample, centrifuged and dried for powder sample. Antibacterial activity of AgNPs is tested against Escherichia coli (E.coli), while morphology, element analysis, and optical properties are determined by using scanning electron microscopy (SEM), energy-dispersive X-ray (EDX), and ultraviolet-visible spectroscopy (UV-Vis). The results show blue shift for the graph of UV-Vis, EDX shows 64.19% of Ag presents, zone of inhibition of AgNPs is around 7 to 13 mm, and no nano particles exist as refer to SEM images.

1. Introduction

Nanoparticles, with their unique properties, have revolutionized various fields like electronics, optics, and environmental remediation [1]. However, conventional synthesis methods face challenges in sustainability, safety concerns and nanoparticle aggregation. To tackle this, green synthesis methods have emerged, using eco-friendly reagents, excluding the uses of chemical reagents.[2] These approaches offer precise control over size, shape, and composition while reducing environmental impact and costs for large-scale production [3][4]. Moreover, nanoparticles exhibiting antibacterial properties are garnering attention for enhancing antimicrobial agents. Evaluating their efficacy against different bacteria offers insights for medical devices and antibacterial coatings [4][5].

Silver nanoparticles possess remarkable antibacterial properties, effectively inhibiting the growth of bacteria, fungi, and viruses by disrupting cellular functions and processes, leading to cell death. This attribute is valuable in medical, industrial, and textile applications [6].

Another important characteristic of silver nanoparticles is their plasmonic behaviour. Plasmons are collective oscillations of electrons in metal nanoparticles, and in the case of silver nanoparticles, they give rise to a phenomenon called localized surface plasmon resonance (LSPR). LSPR causes the absorption and scattering of light at specific wavelengths, resulting in vivid colours and optical effects. This property is utilized in applications such as sensors, imaging, and surface-enhanced spectroscopy [7].

Additionally, these nanoparticles exhibit significant catalytic activity, acting as efficient catalysts for diverse chemical reactions due to their large surface area and unique electronic structure. They have demonstrated effectiveness in reducing environmental pollutants like 4-nitrophenol [8] through processes such as pulsed laser deposition.

Moreover, silver nanoparticles possess excellent electrical conductivity. Since silver in bulk exhibits a high electrical conductivity, silver nanoparticles have the potential to have even higher conductivities when scaled down to the nanoscale. This property is helpful for electronic applications where silver nanoparticles are used in conductive inks, printable electronics, and electronic circuit applications [9][10].

This study aims to use green tea extract to synthesis silver nanoparticles (AgNPs) and explore their morphology, optical, and antibacterial effects against *Escherichia coli*, potentially leading to less toxic and effective antibacterial agents.

2. Materials and Methods

2.1 Materials

The green tea leaves whose brand name BOH tea was purchased from the convenient store located at Pagoh Jaya. Solid crystalline of silver nitrate (AgNO_3) was obtained from Applied Science Laboratory of Universiti Tun Hussein Onn Malaysia, originally from Sigma Aldrich. *Escherichia coli* bacteria strains was obtained from the Food Microbiology Laboratory of Universiti Tun Hussein Onn Malaysia.

2.2 Method

2.2.1 Extraction of Green Tea Leaves

The method of extraction of green tea leaves was performed according to [11] with some modification. First, 8 g of green tea leaves were added to beaker containing 100 ml of deionized water and heated at 80°C for 1 hour. The mixture was then cooled down and filtered by Whatman No.1 filter paper, stored in refrigerator at 4°C and used within one week.

2.2.2 Synthesis of AgNPs by Green Method

For synthesis of AgNPs, we first prepared 0.01 mol/L solution of AgNO_3 by mixing 0.169 g of solid crystalline AgNO_3 with 100 ml of deionized water. It was then mixed with green tea extract prepared earlier with volume ratio of 1:9 and stirred with magnetic stirrer at 800 rpm for 24 hours in dark to avoid photo activation of AgNO_3 . After stirring, the mixture was centrifuged at 10000 rpm for 20 minutes. Then, the liquid of the mixture was then removed carefully with dropper, and the remaining residue was dried inside an oven at 80°C for 1 day. The dried residue was extracted out and stored at room temperature in dark for further uses.

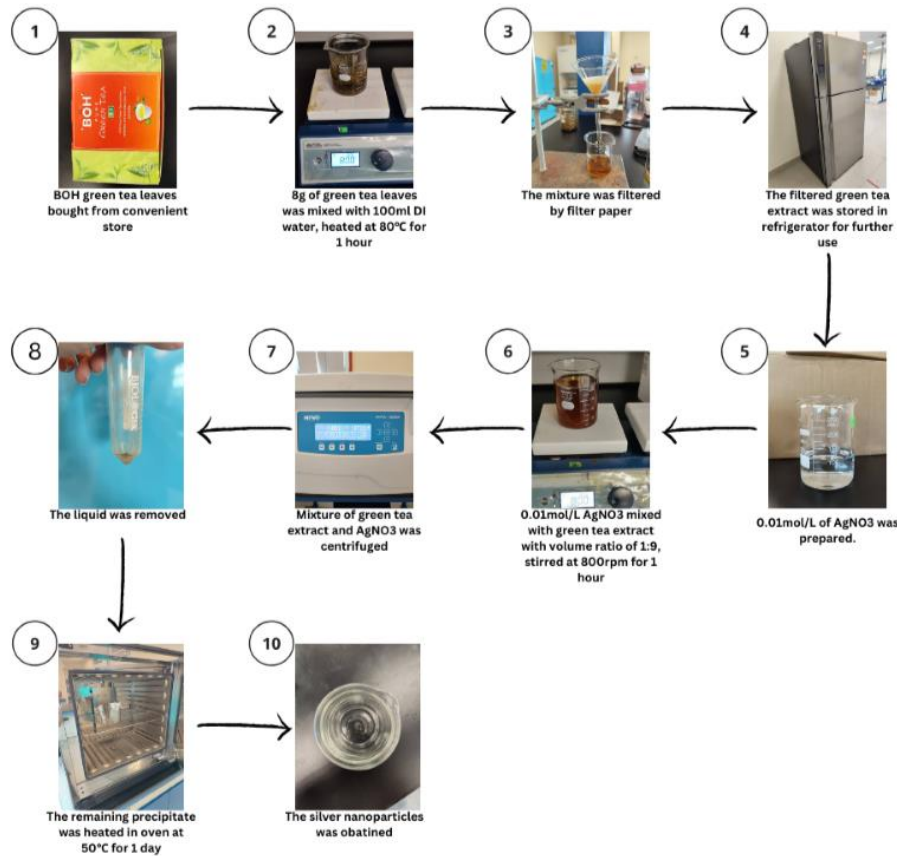


Fig. 1 Experiment Procedure of Synthesis of AgNPs

2.2.3 Characterisation of AgNPs

Ultraviolet-Visible (UV-Vis) Spectroscopy

The spectrum of absorption of light for the liquid sample of the green tea extract, 0.01mol/L of AgNO₃, sample AgNPs, and the reference AgNPs were determined by using the UV-Visible Spectrophotometer Double Monochrome U-3900H within 200 to 800 nm wavelength range and ± 0.1 nm wavelength accuracy.

Antibacterial Activity of AgNPs

The Agar Well Diffusion method was used to determine the antibacterial activity of AgNPs against the Gram-negative bacteria, E.coli. First, 2.3g of agar nutrients powder was mixed with 100ml of distilled water, autoclaved for 15 minutes at 121°C, 15 Psi to sterilize it. After that, the agar was poured in a clean petri dish and allowed to cool. The E.coli was then being subculture by streak method. Then, several wells were created by using sterile cork borer, allowing the liquid sample of AgNPs to be incubated for 24 hours at 37°C.

3. Results and Discussion

3.1 Synthesis of AgNPs by Green Tea Extract

The formation of AgNPs is indicated by the colour change of the mixture AgNO₃ and green tea extract. As refer to Fig. 2 and 3, the colour of the mixture has changed from deep brown to light brown [12]. The phytochemicals present in plant extracts, such as phenols, flavonoids, terpenoids, ascorbic acids, aldehydes, and ketones, are what enable the green tea extract to convert silver ions into silver nanoparticles [13]. The powder form of AgNPs were made as shown in Fig. 4 for the purpose of characterisation of SEM and EDX.

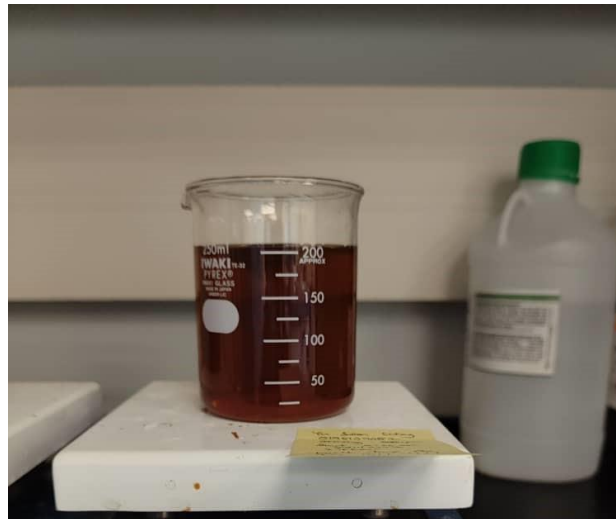


Fig. 2 Mixture of AgNO_3 and Green Tea Extract Before Stirring

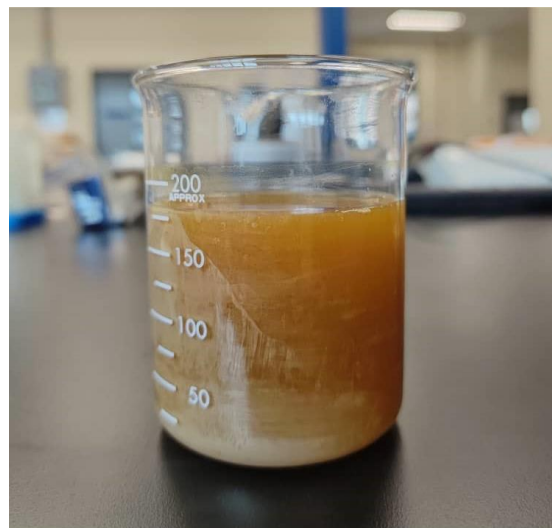


Fig. 3 Mixture of AgNO_3 and Green Tea Extract After Stirring

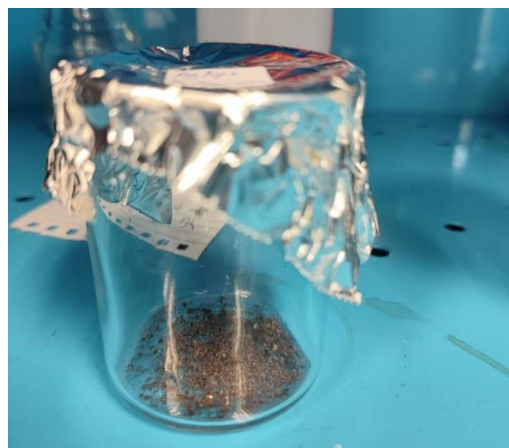


Fig. 4 AgNPs in Powder Form After Centrifugation

3.2 UV-Vis Spectroscopy

The normalized graph of absorbance against wavelength is shown in Fig. 5. For the graph of absorbance of green tea extract, there are several peaks found. The chemical composition of the green tea extract includes polyphenols, caffeine, theobromine, theophylline, methylxanthines, organic acids, amino acids, and other flavour compounds [14]. As referred to the UV-Vis spectrum of National Institute of Standard and Technology (NIST) Standard Reference Database Number 69, the peaks that fall in wavelengths between 200 to 290 nm is due to the existence of caffeine, theobromine, and theophylline in the green tea leaf extract.

The graph of absorbance of AgNPs (reference) peaked at 405 nm, as compared to the graph of absorbance of the liquid sample of AgNPs, which peaked at 375 nm. The graph of absorbance of liquid sample of AgNPs is shifted towards shorter wavelengths, which is the blue shift of the light absorption, indicating a higher energy absorption, small and uniform size of the synthesized AgNPs, and decrease of particles size with increase of citrate concentration [15][16][17]. This change indicates that the synthesis conditions have a direct impact on variations in particle size, homogeneity, and energy absorption capacity. The relationship between the shifted absorbance peaks of AgNPs and the spectrum analysis of the green tea extract highlights the essential role that substances or synthesis parameters play in defining the optical properties and characteristics of nanomaterials.

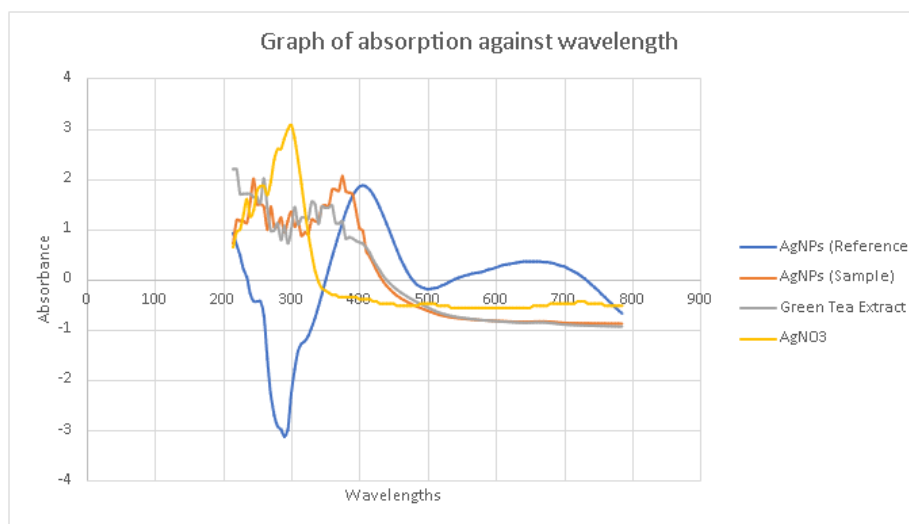


Fig. 5 Graph of Absorbance against Wavelength

3.3 Antibacterial Property of AgNPs

The zone of inhibition of the AgNPs, as shown in Fig. 6, were around 7 to 13 mm, indicating the antibacterial activity of AgNPs against the E.coli.

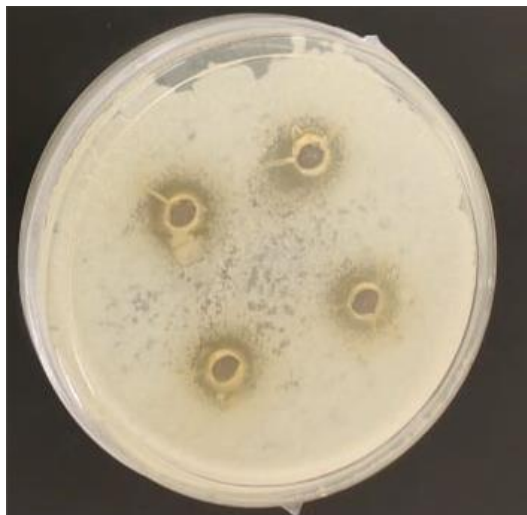


Fig. 6 Antibacterial Activity of AgNPs against E.coli

3.4 Morphology and Element. Analysis of AgNPs

Fig. 7 to 11 shows the SEM images of the powder AgNPs. From the images below, it does not show the nano size particles of the AgNPs. There might be several reasons that contribute to this, including the potential degradation of nanoparticles during imaging. The electron beam used in SEM can cause the formation of a passive organic contamination layer, leading to a loss of catalytic activity [18]. There might also be some agglomeration of AgNPs produced with biosynthesis method [19,20], contamination of particles, etc.

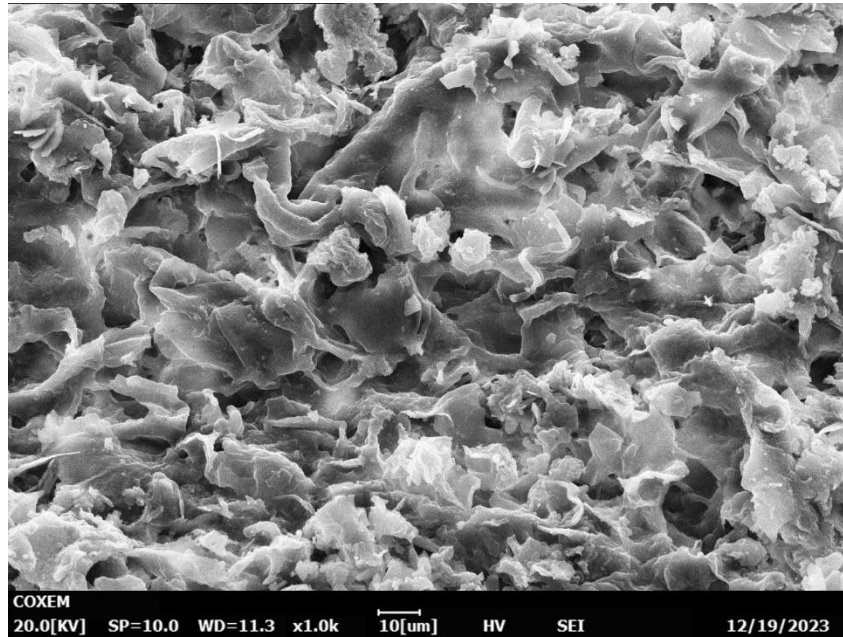


Fig. 7 SEM image of AgNPs

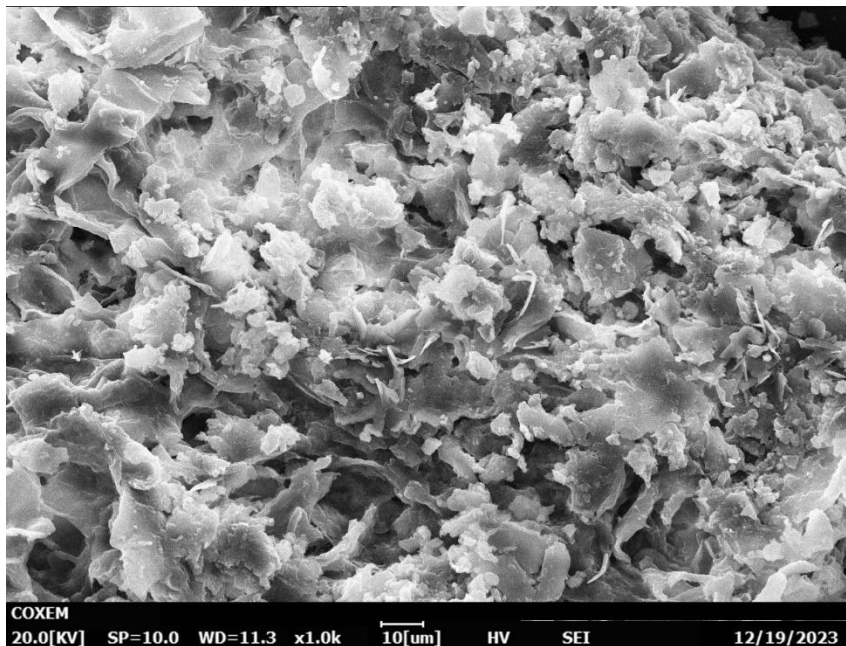


Fig. 8 SEM images of AgNPs

The element analysis of AgNPs derived from EDX spectroscopy is displayed in Fig 9. The collected data was recorded as Table 1. The findings indicate that Cl (16.12%), K (9.48%), Ca (10.12%), and Ag (64.19%) were present in the sample AgNPs powder. This shows that using green tea extract to produce AgNPs was successful since there is Ag present in the sample.

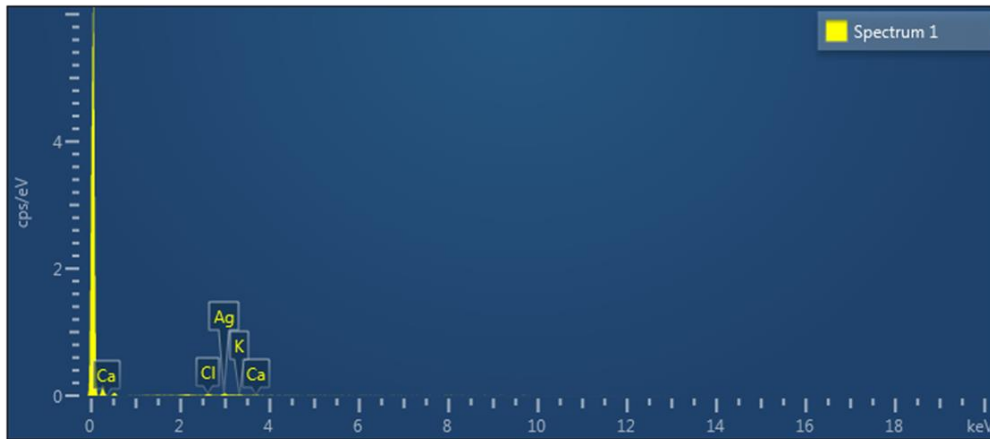


Fig. 9 Element Analysis of AgNPs

Table 1 Data of AgNPs Obtained from EDX

Element	Line Type	Weight %	Weight Sigma	Atomic %
Cl	K series	16.12	2.40	29.39
K	K series	9.48	2.32	15.67
Ca	K series	10.21	2.88	16.47
Ag	L series	64.19	4.12	38.47
Total		100.00		100.00

4. Conclusion

The AgNPs were successfully synthesized with green tea extract with the method mentioned above. From the results obtained from the characterisation, the absorbance of the AgNPs shows a blue shift as compared to previous studies, which is possibly indicate increased energy absorption, small and consistent synthesized AgNPs, and a reduction in particle size as citrate concentration increases. The AgNPs produced shows antibacterial activity with the zone of inhibition of 7 to 13 mm. For morphological characteristics, it does not show the nano size particles for the powder form AgNPs. It may be due to the degradation of the particles, agglomeration, and contamination of the particles. Finally, the element analysis of the AgNPs show that the AgNPs contained Cl (16.12%), K (9.48%), Ca (10.12%), and Ag (64.19%).

Acknowledgement

This research was support by Universiti Tun Hussein Onn Malaysia (UTHM). The authors are deeply thankful to the diligent laboratory staff at FAST for their expertise, guidance, and collaborative efforts, which significantly contributed to the success of this research project.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design, data collection, methodology, analysis and interpretation of results:** Yu Soon Wing and Syed Zuhaib Haider Rizvi. All authors reviewed the results and approved the final version of the manuscript.

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